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CHAPTER 4

CONCEPTUAL STUDIES

4.1 GENERAL

The formal project development process begins with a conceptual studies phase. The conceptual studies phase identifies and evaluates alternative courses of action (i.e., engineering concepts) to address the highway's transportation needs and deficiencies. This phase advances a project listed in the multi-year program to a point where it is sufficiently described, defined and located to allow the actual design phase to begin. Conceptual studies are closely related to the environmental process outlined in Chapter 3. The environmental reports normally summarize the engineering results of the conceptual studies.

The overall objectives of the conceptual studies are as follows:

- to fully identify and quantify a highway's transportation needs and deficiencies,
- to develop a general course of corrective action, and
- to identify and evaluate with engineering analyses the feasible and reasonable solutions (alternatives) to these needs and deficiencies.

A preferred alternative is selected after the options have been jointly evaluated in the environmental phase. Assuming the preferred solution involves some form of highway upgrading, the conceptual study phase concludes with the selection of a preferred alternative with the scope of work defined by a category of improvement, geographical corridor and preliminary highway design standards. The formal identification of the preferred alternative occurs in the final approved environmental document and this constitutes location approval.

4.2 GUIDANCE AND REFERENCES

The regulations, policies, guides and references that provide the background for implementing conceptual studies are listed in Section 1.2.

For additional references on specific subjects, refer to the guidance and reference section in the appropriate Chapters of this *Manual*. The listings are not all inclusive and other documents may contain useful information in special situations.

4.3 INFORMATION GATHERING

Data collection is an integral step in the conceptual study process. The following subjects are the most common areas where comprehensive information must be gathered for highway location analysis.

4.3.1 Needs Studies (Planning Reports and Inventories)

These documents provide system-wide highway information on the physical condition, current deficiencies and future needs of routes on a system. General types of needed improvements and approximate construction cost estimates are also reported and can be used to develop a priority list of projects.

While this information is primarily used to show revenue needs or assists the priority setting/programming process, it can provide a good starting database for conceptual studies. Usually, needs studies are general in nature and must be expanded and refined into specific project data, issues and details.

The NPS "Road Inventory and Needs Study" and the 1983 "Forest Highway Inventory and Improvement Study" are examples of studies conducted by FHWA's Federal Lands Highway Divisions. Federal-Aid Divisions and State transportation agencies routinely conduct other needs studies, which may be useful on Federal Lands Highway projects.

4.3.2 General Design Criteria

General design criteria are used to describe and evaluate highway improvement alternatives in conventional engineering terms, so that a highway's physical, structural, safety and operational characteristics can be readily understood. While many elements of design (e.g., stopping sight distance, grades, horizontal/vertical alignment, superelevation) must be established to conduct a detailed highway design, only a few elements are essential at the conceptual stage. Roadway width (i.e., lanes, shoulders), design speed, surfacing type and corridor location are the main criteria for studying highway alternatives. Other features (e.g., side slopes, ditch widths, clearing limits) should also be identified if the total width of project disturbance appears to be a critical consideration. (See Exhibit 4.3-A.)

4.3.3 Traffic Characteristics

Traffic plays a major role in establishing the concept and design of a highway. Traffic indicates the type of service for which the improvement is being made and directly affects the geometric features of design (e.g., widths, alignment, grades).

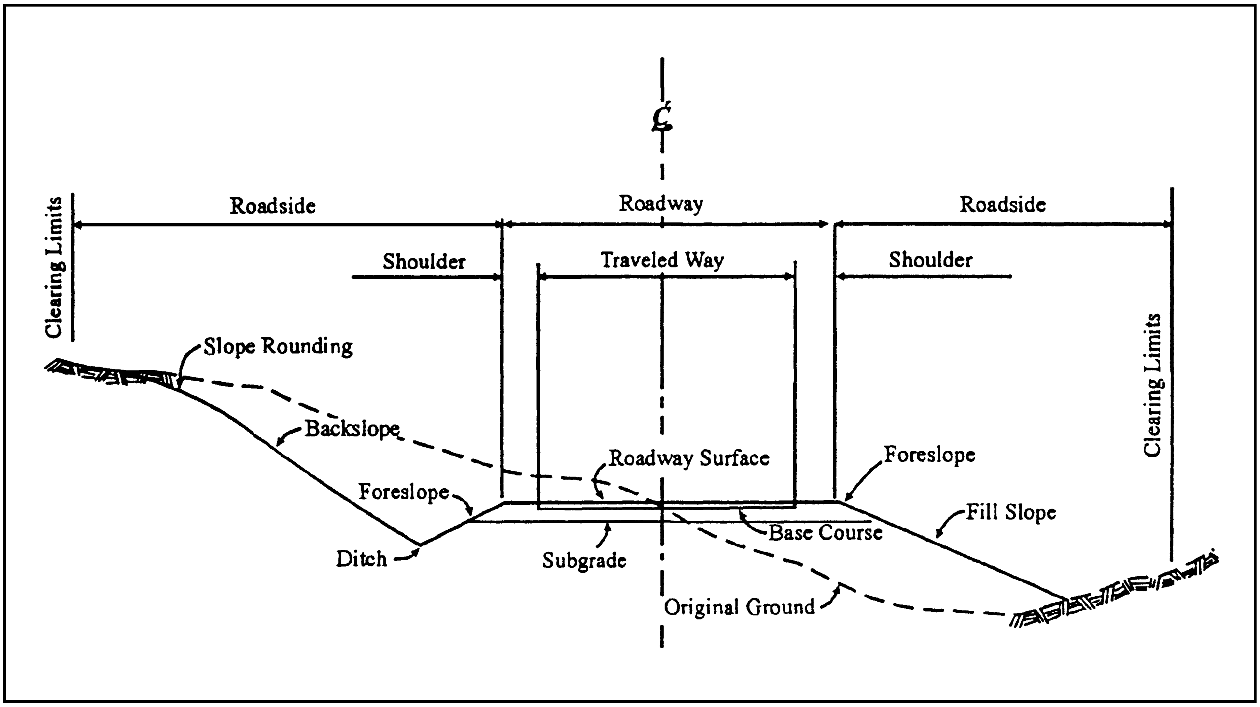


Exhibit 4.3-A TYPICAL ROAD CROSS SECTION ELEMENT

General traffic data (e.g., average daily traffic, vehicle classification) is collected on almost a continuous basis by most highway departments and some land management agencies. This information can be readily obtained and provides a benchmark for traffic data in the study area. When traffic data is not present, it must be developed by special counts or by calculating the number of vehicles from related information (e.g., National Park visitations, cubic meters (feet) of timber hauled, recreational visitor days).

The AASHTO *Green Book* in Chapter 2, *Traffic Characteristics* provides an excellent description of traffic characteristics (e.g., volume, directional distribution, composition of traffic projections, speeds). While much of this information has a more direct bearing on design details, conceptual studies and associated alternative analyses are also dependent on overall traffic data. Sometimes traffic data (e.g., operating speeds, travel time and delay, occupancy rates) are needed to address a special issue. If this data is unavailable, traffic studies as described in ITE's *Transportation and Traffic Engineering Handbook* should be conducted to provide this information.

4.3.4 Crash Data

Vehicular crash data can provide excellent guidance in determining a road's past problems. These statistics are usually maintained and readily available at the highway department, land management agency and/or the law enforcement office responsible for that highway facility. When this type of data is not immediately available, a short-term avoidance study or an assessment of crash potential should be conducted.

Figures for crash rates are currently shown in crashes per million vehicle kilometers (miles) traveled. Figures for fatality rates are currently shown in fatalities per one hundred million vehicle kilometers (miles). FHWA plans to keep this figure for at least several more years, but will supplement it with fatalities per one hundred million vehicle kilometers (miles) beginning with FHWA's 1994 *Highway Statistics Report*. Chapter 8 describes in detail how crash rates fit into the safety analyses of highways.

4.3.5 Environmental Considerations

A highway has wide-ranging effects beyond that of providing traffic service to its users. It is essential that the highway be considered as an element of the total environment. The highway can and should be located and designed to complement its environment and serve as a catalyst to environmental improvement.

Conceptual studies are conducted concurrently with the environmental process and each has a major effect on the other. As outlined in Chapter 3, close coordination is important to ensure the range of improvement alternatives is established in recognition of overall environmental factors. This allows for an orderly, complete evaluation when determining the preferred improvement alternative. Also, design of the preferred alternative must reflect the mitigation commitments identified in the environmental phase.

4.3.6 Reconnaissance Study

The reconnaissance study or survey is a traditional term given to the engineering process now called conceptual studies. Originally, it was associated more with the investigation and evaluation of road corridors on new alignment. In contemporary terms, the field inspections and engineering involved with identifying and quantifying a highway's deficiencies and needs, developing a course of action with improvement alternatives and conducting engineering analyses that result in a preferred alternative are collectively called a reconnaissance study. Project planning study, route study, feasibility study and preliminary engineering study are all terms used by different agencies and offices to mean some form of reconnaissance activity that falls within the conceptual study phase.

4.3.7 Aerial Photography and Mapping

Aerial photography and mapping, as described in Chapter 5, Sections 5.3 and 5.4, generally provide very valuable and essential data in the study and illustration of highways, roadside features and proposed highway improvements. Detail maps and sometimes mosaic photo composites developed specifically for the highway in the study area are needed in the conceptual study stages when improvements include new corridors or substantial widening, and/or curve flattening. USGS quadrangle maps or aerial photographs from other agencies can be obtained that suffice or assist in the conceptual studies, especially when more minor improvements are being investigated.

Oblique and terrestrial photography can be helpful in studying proposed improvement corridors and can be enhanced by photomontage techniques to illustrate future highway improvements. These techniques require a preliminary design (e.g., cross section, earthwork), which can be a time-consuming and labor-intensive program.

4.3.8 Geotechnical Reconnaissance

Preliminary geotechnical information should be obtained early in the conceptual studies phase by specialists in this field of engineering. This will assist in determining the cause for instability or pavement problems on the existing highway and provide information on potential problems for constructing the alternatives under consideration. Subsurface investigations in the study area may be required if existing information is inadequate and/or incomplete.

Typically, a geotechnical reconnaissance report addresses the following:

- geology of the study area;
- existing and/or potential unstable soil conditions;
- location of possible sources or sites for base, surfacing and topsoil materials; and
- estimated surfacing requirements.

More in-depth investigations are conducted later in the project development process as described in Chapter 6, Section 6.3.

4.3.9 Hydraulic Information

Where water resources affect the road corridor (e.g., flood plains, erosion, drainage, water quality), hydraulic information should be obtained for the conceptual studies stage by specialists. This data aids in determining the cause of some road problems and, more importantly, provides guidance to determine feasibility, location or size of hydraulic structures for the alternatives under consideration. This data is needed more to address environmental concerns and establish a datum than to resolve engineering design problems, which are addressed in the design phase. See Chapter 7 for obtaining detailed information about hydraulic data and procedures.

4.3.10 Public Involvement

Public involvement is a formal environmental process requirement. It provides necessary input and benefit during conceptual studies. As outlined in Chapter 3, Section 3.4, it is important to publicly announce the beginning of the conceptual studies phase, especially for the larger scale projects. This can help in identifying the local perspective on the major highway problems and driving difficulties along the route. Once alternatives have been developed, public input can be obtained through the environmental review process for the proposed improvement alternatives and their respective scopes of work.

4.4 LOCATION ANALYSIS

The location analysis combines preliminary investigations by nearly all the transportation engineering disciplines (e.g., traffic engineering, survey/mapping, geotechnical, hydraulics, structural engineering, roadway design) into a coordinated comprehensive assessment of a highway's transportation problems and a feasibility study of possible solutions. The analyses involve evaluating diverse field data, yet the analyses are preliminary or general in nature. A higher degree of technical detail is necessary in the design phase.

The types and sequence of steps in the conceptual study process are described in the following subsections. The technical analyses are not always presented in depth, but references are given to the other Chapters where the preliminary and detail design requirements are discussed.

4.4.1 Course of Action

Depending on the degree of investigation and analysis in the planning phase, a project's proposed course of action, as it enters the conceptual study stage, could vary greatly, from a simple description of study area limits to a specific course of action (e.g., replacement of a particular bridge). To fully develop a complete, specific course of action, the overall highway deficiencies and transportation needs must be well identified, quantified and evaluated in the conceptual studies.

The first step is data collection. This consists of an inventory of the physical features and operational characteristics of the existing highway. Most of this information is available from the highway agencies (e.g., highway departments, Federal land management agencies), road monitoring reports and planning/reconnaissance studies. The designer should determine and verify with field inspections the road's length, width, surfacing type, traffic control devices and roadside features along with their current condition. In addition, the road's maintenance condition and recurrent problems are important and should be documented. Also, general traffic data and operational characteristics including seasonal variations, peak use, vehicle types and their volume percentages should be obtained. Travel information like running speeds, congestion periods or any irregularities should be determined. Typically, the maintenance forces have many observations to offer. The quantity of other road users (e.g., bicyclists, pedestrians) must also be established.

Do not overlook winter driving conditions including problems of removing snow and ice. Rural farming areas may also present unique problems of moving farm machinery on the highway.

The current traffic crash statistics for the route should be obtained. This must be supplemented with field identification of potential crash sites that may not be discernible from the past data.

After gathering the data, compare the existing road and its current functional classification, geometric standards, physical condition and present travel demand with the highway agency's road standards. If the highway agency has separate RRR geometric standards and design procedures, determine if they apply to the project. AASHTO's *Green Book*'s geometric standards are broad enough to address most types of roads if there are no other standards that apply. A listing of the road's current deficiencies, both physical and operational, and relative importance of each should be prepared to indicate where the road is substandard and not functioning properly. Exercise care when determining the major contributing factors of a defective road facility. Do not automatically assume an existing substandard road feature is the problem.

Next, the long-term needs of the highway and its users must be determined. This is based on projections of how land use activities in an area are going to change along with their associated transportation requirements. Long-term transportation needs are commonly described by a forecasted 20-year ADT and percentages of vehicle types (e.g., trucks, buses, recreational vehicles), in the travel stream. Other factors like urbanization of the roadside and functional classification changes also directly affect future needs.

The land management agencies through their planning offices and area-wide comprehensive planning documents (e.g., NPS General Management Plan, NPS Development Concept Plans, NFS Forest and Resources Management Plans) can provide some information and assistance in determining future travel demands on highways. Comparing the current highway facility with the geometric standards of a road that is sized to accommodate its future traffic volumes and travel conditions will usually indicate the extent of upgrading that may be warranted to address the long-range transportation needs.

To establish a proposed course of action, one must recognize the existing road, its deficiencies and future needs, the user needs, the context of the facility, and then describe the type of improvement required to create a highway that meets objectives. The objectives are typically to provide a facility to the highway user that fulfills the following:

- fulfills the operational and safety needs of the users,
- meets the convenience and safety standards for that system of highways,
- is cost-effective to build,
- avoids or minimizes environmental impacts, and
- minimizes maintenance costs.

A typical course of action addresses the road's width, alignment, surfacing, major structures, roadside features, and the general types of construction items needed to implement these improvements. Example 4.4-1 provides a sample of a typical course of action.

Example 4.4-1

> Route 1 is to be upgraded between A and B by widening to provide two continuous traffic lanes and shoulders. The horizontal and vertical alignment will also be flattened and corrected to provide a uniform design speed. The road will be stabilized, paved and delineated with standard traffic control devices. The bridge over Clear Creek at Kilometer (Mile) 198 will be replaced. The principal

items of work consist of clearing, grading, drainage, base, asphalt surfacing, signing, striping and bridge construction.

The intent is to describe the type of proposed improvements, but allow flexibility so various alternatives can be considered that will accomplish the proposed course of action.

4.4.2 Alternatives

Once the proposed course of action is established, the next step is to identify all reasonable alternatives that can accomplish the objectives. These should be practical engineering solutions to the identified problems (e.g., current deficiencies, future needs) within the overall limits of the course of action.

Initially, alternatives might cover quite a range or scale of improvements, but they should be condensed to three or four succinct alternatives for which further engineering analyses can be applied. Otherwise, the details, data and description become very cumbersome to handle. The basic categories of alternatives to be considered on most road upgrading are described in the following Sections.

4.4.2.1 No Action

The no-action alternative would only continue the routine maintenance of the facility and does not include any upgrading that would change the road's operation or extend its service life.

4.4.2.2 Transportation System Management (TSM)

This alternative should always be considered when upgrading a road. It consists of travel controls and/or limited construction to maximize the operation and efficiency of the existing facility without major reconstruction or new construction. Sometimes these controls might include one of the following:

- accommodating the existing traffic on other routes or with different types of vehicles;
- posting vehicle restrictions and load limits; and
- providing an alternate, more attractive mode of transportation.

This form of TSM alternative is only marginally effective for Federal Lands Highway Programs because of the outdated, rural highway systems and automobile dependency present in most FLHP situations.

Resurfacing, restoration or rehabilitation (RRR) projects are TSM alternatives with limited construction efforts that can be very cost-effective. The objective is to preserve and extend the service life of the existing highway and enhance safety without substantial costs, construction impacts or major right-of-way acquisitions. Generally, RRR projects are not reconstructed to full geometric standards.

RRR work is undertaken to preserve and extend the service life of an existing highway and enhance highway safety. This may include placement of additional base and surface material and/or other work necessary to return an existing roadway to a condition of structural or functional adequacy. The RRR work is generally done on existing alignment. This salvages a substantial amount of the existing surfacing, but may include some upgrading of geometric features (e.g., minor roadway widening, flattening curves, improving sight distances).

RRR projects are customized for individual situations and often result in exceptions to conventional standards. The improvements, whether only at spot locations or continuous, should acceptably meet existing and preferably future (i.e., 10 to 20 years) traffic needs and conditions in a manner conducive to safety, durability and economy of maintenance. Usually, the RRR project only addresses the most critical deficiencies of the highway so the resultant condition will still have some problem areas/substandard features that would be addressed as part of a future reconstruction. The agency with jurisdiction of the road may have separate design standards and procedures that apply to RRR projects.

Substandard geometric design elements require approval as design exceptions (see Chapter 9).

4.4.2.3 Reconstruction

This is an improvement alternative that rebuilds a highway essentially along the same alignment and when the retention of the pavement structure is not a primary objective.

Reconstruction work normally involves a substantial construction effort to rebuild the existing highway to at or near full geometric/safety standards.

The complete spectrum of design deficiencies and functional obsolescence of the roadway, as well as future transportation needs, should be addressed by this level of upgrading. Typical work includes widening, realignment and replacement of bridges. While reconstruction, by nature, follows an existing road corridor, it may deviate significantly in width and alignment from the present road to obtain its full geometric standards.

4.4.2.4 New Construction

This is an improvement alternative to build a road and/or bridge on completely new alignment or substantially upgrade a highway facility along an existing alignment providing new access to or through an area.

Usually, the highway is built on new alignment in a virgin corridor. It normally is constructed to full geometric standards to fulfill both the current as well as long-term transportation needs of the area.

4.4.3 Preliminary Design Standards

Proposed highway improvement alternatives are principally described by preliminary design standards. The design standards listed in *FLHM* 3-C-1 can be supplemented or substituted with approved highway design standards from owner agencies. These substitutions must be consistent with the highway program legislation, regulations and interagency agreements discussed in Chapter 2, Section 2.3 and 2.4.

While the categories of alternatives indicate the overall level of upgrading, more specific terms must be used to describe an alternative beyond the general course of action to evaluate its operational, safety and structural characteristics. The roadway width, design speed and surface type are the main elements of the general design criteria used to describe an alternative's preliminary design standards. Other elements (e.g., full typical roadway cross section, preliminary line and grade, grading/clearing limits, auxiliary lanes/tapers, right-of-way widths) are sometimes included when the environmental analysis requires more specific information to evaluate roadside impacts.

The intent of conceptual studies is not to develop the design of the project, but to provide direction and scale of the improvement. Given this direction, the designer should develop the most cost-effective design of the preferred alternative.

A good conceptual study should do the following:

- identify, evaluate and compare benefits and impacts of each alternative;
- establish design flexibility;
- define commitments to protect and preserve the environment; and
- provide long-term planning guidance.

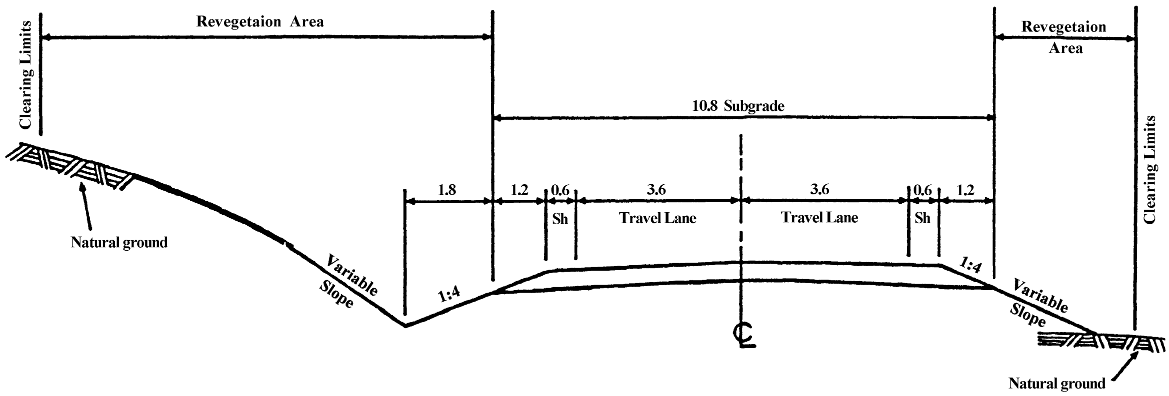
Preliminary concept studies define the project by line and grade, right-of-way limits, construction quantities and roadway geometrics in general terms based on projected traffic volumes, terrain and other special features. During the design phase of the project, these activities will be addressed in more specific detail (see Chapter 9).

To establish the preliminary geometric design standards of roadway width and design speed, it is necessary to know the corridor's predominate terrain (i.e., level, rolling, mountainous), the functional classification of the route and the traffic volumes (i.e., current/future ADT) of the highway.

While, in many cases, the minimum AASHTO geometric standards will provide the most appropriate level of safety, convenience and operational efficiency, alternatives with different standards must also be considered to address any special factors (e.g., economic, environmental, operational) that affect the road, its users and context. Gathering and evaluating diverse land use, transportation, environmental and economic data, together with applied engineering judgment and analysis, will aid in formulating practical improvement alternatives above and/or below the minimum full standards.

The preliminary design standards used to describe the alternatives provide guidance for establishing other criteria to be used in the design process. Many of these other elements are functions of the ADT, design speed or roadway width and are set during the design activities. The preliminary design standards, as well as the other design standards and criteria, become the final adopted project standards when the design approval is issued (see Chapter 9).

Exhibit 4.4-A is an example of how to show and describe an alternative and its preliminary design standards. This information should also be supplemented with a map depicting the location of the alternative as discussed in the next Section. When comparing numerous alternatives, it can also be effective to display them together in a conceptual setting.



ALTERNATIVE A

Note: This alternative for the reconstruction of 105 km (65 mi) of Flat Mountain Road by widening and adding bituminous surfacing to obtain a 8.4-m (27.5-ft) wide roadway consisting of two 3.6-m (12-ft) paved lanes and two 0.6-m (2-ft) paved shoulders. Roadside features such as 1V:4H foreslopes, variable ditch widths and backslopes with minimum selective clearing are included to provide a reduced, but adequate cross section with standard sight distances and roadside safety.

The horizontal and vertical alignment of the existing road will be adjusted by curve flattening, grade raises and short relocations to provide a minimum 60 km/h (40 mph) design speed. Necessary widening will be provided with the least effect on natural features and private property. Generally, widening will be made on the roadside away from the river or other sensitive features (e.g., wetlands).

The bridge over Deep Creek at km 20.1 (mi 12.9) is to be replaced in approximately the same location. The existing right-of-way can be used in constructing much of this alternative. Partial takings from parcels along the existing roadway totaling approximately 0.93 ha (2.3 ac) will be required for widening, improving the site distance and reducing the severity of curves.

The proposed improvement of FH 72 begins at km 20.8 (mi 12.9), which is the northern terminus of previous improvements and generally follows the existing road to the vicinity of Dutch Road, about km 20.4 (mi 12.7). At this point, an alignment shift is proposed 60± m (200 ft) to the east of the existing road. This approximately 600-m (2000-ft) long relocation would avoid a congested area formed by residences and commercial property bordering the east side of the existing road and a historic mine site bordering the west side. The proposed improvement connects with the existing road at about km 20.9 (mi 12.9) and generally follows it northerly to its terminus at an intersection with US 22 (km 30.2 (mi 18.7)).

Exhibit 4.4-A TYPICAL PRESENTATION OF AN ALTERNATIVE

4.4.4 Highway Corridor

When formulating improvement alternatives, it occasionally becomes apparent that a highway should be considered on new alignment in a corridor outside of the existing road. In fact, there may not even be a road connecting the termini, although this situation is not common.

New highway corridors are usually identified and evaluated separately from an alternative's preliminary design standards although they must be compatible with all the components that make up the alternatives. A highway corridor can be defined as a linear strip of ground that connects termini and has sufficient width and variable positioning on the terrain to allow a road with its preliminary design standards to be built within its borders.

Depending on length and terrain, most corridors are between 30 m (100 ft) to 120 m (400 ft) wide. Its position on the topography is tied to existing land forms and sometimes defined in relation to a survey traverse line (see Chapter 5).

Highway corridors are normally established with three general objectives in mind:

1. **Size**. The corridor must be broad enough to allow the highway centerline to be positioned or shifted in conformance to the geometric standards and to achieve reasonable cost effectiveness.

2. **Features**. The geographical and geophysical features should be stable and compatible with the construction, operational and maintenance requirements of the highway.

3. **Environmental Impacts**. The environmental impacts should be minimized and aesthetics maximized.

Historically, the process of investigating new highways and corridors was called a location survey or reconnaissance study. Currently, much of the process is covered by the environmental analysis and documentation. However, the basic procedures in establishing feasible highway corridors are still valid.

A thorough initial investigation is essential in making effective corridor determinations. If the most feasible, serviceable and economical corridor is not determined at this stage, no amount of engineering effort can overcome the inherent deficiencies that will exist. When presenting corridor evaluations, it is imperative that the same basic data and methods of investigation be used for each corridor studied.

Most corridor reconnaissance work is done using photogrammetric or other topographic maps supplemented with field data. On occasion, ground reconnaissance surveys are made as a substitute for or supplement to the topographic mapping.

Before beginning the study, the reconnaissance engineer should review all available maps and photographs to determine if any additional data and mapping are needed for conducting the study.

The following information is pertinent to corridor studies:

- land use, population and density;
- geophysical and geological formations;
- potential of the area for future industrial, residential, farm or recreational development (i.e., land use changes);
- frequency, condition and type of existing roads and highways serving the area;
- existing utilities and facilities, planned and potential (e.g., transportation (other than highways) dams, power lines, gas and water lines, recreational areas); and
- photographs of controlling features.

4.4.4.1 Mapping Requirements

The type and scale of mapping required for the advance planning study are dictated by the terrain and land use intensity of the route corridor area and the level of preliminary design analysis to be conducted. The maps must be complete, current and provide full details of topography and physical features.

Mosaic reproductions or photographic prints may be used to show routes or portions of routes. The route plan should be made to the same scale as the mosaic copies. If oblique photographs are used, they should show the route in contrasting lines and should be delineated legibly. The date of photography should appear on the maps.

Mapping for areas of moderate to intensive land use should be to a scale of 1:1000 (1:1200) or 1:2000 (1:2400) with a 1-m (5-ft) or 2-m (10-ft) contour interval. In areas of limited or homogeneous land use and in mountainous or heavily timbered areas, a map scale of 1:5000 (1:4800) with a 3-m (10-ft) or 5-m (20-ft) contour intervals will suffice. If only broad reconnaissance is to be done, existing USGS quadrangle maps with their 1:24,000 scale may be adequate.

The photogrammetric mapping may be used where feasible and where its use is cost-effective. Further mapping discussions are contained in Chapter 5.

Photogrammetric maps, topographic maps and aerial photographs of the area are good references and may be obtained from the following sources:

- previous surveys and reports;
- maps by Federal, State, county and municipal agencies;

- quadrangle maps by US Geological Survey (USGS), US Coast and Geodetic Survey and Civil Aeronautics Board;
- hydrographic surveys of rivers and river and harbor surveys by the US Army Corps of Engineers (USACE);
- tideland maps by the State land department;
- surveys by the Bureau of Reclamation, NPS and Bureau of Indian Affairs (BIA);
- highway right-of-way maps by FHWA, State and county agencies;
- township maps by the Bureau of Land Management (BLM);
- maps by Forest Service (e.g., transportation maps, firemen's maps, topographic maps);
- stereophotographs from private sources and government agencies, particularly the USGS and the Department of Agriculture;
- geological reports and bulletins;
- railway maps and profiles; and
- maps made by the State planning divisions (i.e., county maps showing county road systems and roadside culture and city maps, which include the immediate surrounding area).

4.4.4.2 Photographs

Ground photographs or oblique aerial photographs should be taken of controlling elements in the field to supplement the mapping. These can be used in analysis, report illustration and for exhibits in the public involvement process.

4.4.4.3 Corridor Selection

Specific procedures should be followed in the selection of route corridors for comparative evaluation. Common points of termini for all routes to be studied should be identified in addition to any constraints that may limit alignment, grade and route location.

Typical constraints include the following:

- Limitations imposed by design standards (e.g., maximum allowable grades and curvature).

- Physiographic controls (e.g., landform and watercourse gradients, shorelines, property or jurisdictional boundaries, preemption of lands for other (usually higher) use) and the avoidance of known problem areas (e.g., unstable, highly erosive land forms).

- Economic controls, including encroachment on high cost lands or improvements, and alternatives involving features of excessively high construction cost.

- Mandated points of contact (e.g., intersection with a limited access facility where the access point is predetermined, access to a major point of interest that has a fixed location).

- Environmental controls, some of which are mandated by law, govern the avoidance of wetlands, prime and unique farm lands, habitat for endangered species, historical and archaeological sites and park lands.

4.4.4.4 Aesthetic Elements

Weigh the aesthetic qualities of the corridors under investigation as carefully as those that contribute to traffic safety, highway efficiency and structural adequacy. Gentle curves, easy grades and lanes with adequate clearance between passing vehicles contribute both to pleasant and safe driving. Both horizontal and vertical alignments should be coordinated to create a total roadway alignment that complements rather than disrupts the natural landform.

Pleasing appearance can usually be achieved at little extra cost if the road is located with these aesthetic elements in mind from the start. Further, roadside development (e.g., scenic vista, angler’s parking areas), erosion control, flattening and rounding slopes, seeding and revegetation contribute significantly to roadway beauty and safety as well as reduce maintenance cost.

When the merits of competing locations are nearly equal, scenic quality may be a deciding factor.

To ensure aesthetics in highway design, accomplish the following:

- Direct the highway toward worthwhile scenic features within reasonable range.

- Locate the highway so that scenic features are large (e.g., mountains, lakes) and directly ahead of the driver’s line of vision.

- Make maximum use of independent horizontal and vertical alignment on divided highways to blend the roadways into the terrain and reduce harsh effects and unnecessary construction scars.

- Coordinate vertical and horizontal curvature. The best appearance is achieved when vertical and horizontal curves coincide, or horizontal curvature leads vertical curvature slightly.

- Avoid short, abrupt horizontal and vertical curves, especially if the central angle is small.
- Avoid long tangents in rolling country. Roller coaster profiles are visually distressing.
- Ensure that sufficient right-of-way area can be provided at ends of tangents and on the inside of curves to permit ample clearing and to prevent erection of buildings or structures that could impair perspective or horizontal sight distance.
- Avoid unsightly obstacles by adjusting the alignment away from the obstacle before it is within the driver's view.

4.4.4.5 Map and Photograph Study

Use a large scale map that shows only the major topographic features (e.g., rivers, mountains, roads, cities, towns) to show the various alternative corridors between the termini. By studying this map, select the more representative alternatives. The most feasible alternatives to be evaluated in detail may then be chosen through a process of elimination.

Next, the locator should intensively study and analyze the collected material before going into the field. If good photographic and map coverage is available, much of the hard work of reconnaissance can be done by stereo aerial photo analysis and map study. Impractical locations can logically be eliminated, freeing the locator to concentrate on the more promising alternatives during the field investigation. Further refinement or elimination of alternatives may occur following the field investigation. The following applies:

1. **Map Study**. Study of the topography between assigned termini will reveal avenues through the terrain that may be followed for a road location and barriers that must be avoided. Ridges or watersheds are often good avenues, and where there are long regular ridges leading in the right direction, the locator is indeed fortunate. Valleys are also excellent avenues if they lead in the right direction. The most difficult locations are those that cut across the natural avenues or those that lie in confusing terrain where the ridges and streams have no continuous well-defined direction.

   Each possible avenue should be examined, though some may be immediately discarded as impracticable. Each practical route should be sketched on the map using different colors or line symbols. Where the gradient might be controlling, the grade contour should be stepped out on the map with a bow divider or equivalent CADD technique to ensure that the route grade is within acceptable limits. Points where curvature may be critical should also be checked.

2. **Stereo Aerial Photo Analysis**. A reasonably good study can be made by stereo examination of aerial photos. It is possible to check gradients using only the stereoscope and an engineer's scale. Possible lines may be sketched on the photos and compared with map locations. Stereo examination will yield information that may not be shown on a map, so if both the map and photos are available, both should be used.

A thorough map or stereo aerial photo study should investigate all possible routes within a band that is 40 to 60 percent as wide as the distance between termini. If adequate photo and map coverages are not available, the locator should view the terrain from a light plane or helicopter before going into the field. Under some conditions it is desirable to have air photos of the route made for use in the reconnaissance.

The time required for the field work of reconnaissance depends on the effectiveness of the preliminary office studies, the accessibility of the route, weather, etc., and might vary from a day to weeks. The field investigation can be made by any means available (e.g., vehicle, horseback, by-foot). During this investigation, the locator observes and keeps notes on the forest cover, drainage, bridge sites, the nature and classification of the soil, rock outcrops, land use and anything else that might affect the location.

4.4.4.6 Major Considerations and Physical Controls

The termini are the major controls of the route. From a strict user's standpoint, the most economical route is a straight line between the termini, both horizontal and vertical.

However, the practical economic location and the environmentally acceptable locations are based on a compromise between construction cost, user's cost and environmental impacts.

Physical controls (e.g., bridge sites, rock areas, valley and mountain sides, built-up areas, lakes and drainages) affect the construction costs.

4.4.4.7 Information to be Obtained

On each corridor studied, the following information should be known:

1. **Termini**. Common study termini should be used even though some routes may use portions of existing facilities that already conform to standards.

2. **Traffic Data**. Assembly of data on traffic and projected roadway use requires a thorough research effort. Primary source agencies are Federal, State and local road administration and planning agencies. In some instances, it may be necessary to conduct special traffic studies as a part of the corridor study. Research and collect all available data on the following subjects:

    - Traffic data on existing facilities:

        + average daily traffic,
        + seasonal average daily traffic,
        + peak hourly volumes, and
        + design hourly volumes.

    - Traffic trends, past and projected.

- Classification of vehicles (percent passenger vehicles, percent trucks and buses and percent recreation vehicles).

- Crash data:

  + route segments, and
  + spot high-hazard locations.

- Directional split.

- Turning movements at major intersections.

- Traffic desire lines.

- Speed and delay data.

- Conflict study data.

Traffic desire lines, speed and delay data and conflict study data are optional depending on specific project requirements.

3. **Right-of-Way**. Identify the existing right-of-way corridor and roughly approximate the proposed right-of-way area. Describe the property affected and the nature of impacts. Estimate the approximate right-of-way cost and any special right-of-way problems. If all or part of the route crosses government land, identify the agency controlling the land.

4. **Geology**. Identify the geology of the general area. Use a geologic map if one is available. Interpret and show the relationship of the geology to the proposed route. Include the location and the extent of the following features:

- landslide areas;

- solid rock;

- unconsolidated material;

- ground water and surface water conditions; and

- availability of road construction materials (e.g., type of deposits, quantity and quality).

Make recommendations for type of materials to be used (e.g., borrow, waste sites, contractor staging areas).

5. **Controlling Factors**. Describe all controlling features involved in route selection. The following provides some examples:

- railroad crossings;
- bridges and other structures;
- high-voltage power line crossings (i.e., record elevation of low point in cable and air temperature);
- problems involving terrain and/or access; and
- utilities and/or special services.

6. **Design**. Describe range of proposed preliminary roadway design standards, especially alignment and grades, roadway sections, type and cost of structures and other preliminary design elements being considered. Many of these are illustrated in a roadway cross section.

7. **Construction Materials**. Describe all construction materials available in the area. Identify pit sites by location and pit number, if known, and give names and addresses of local construction materials' suppliers.

   Depending on the detail and accuracy required, a preliminary design line may have to be developed through the corridor to approximate and represent the alignment and construction cost parameters. The procedures for developing the line and grade projection/information is found in Section 8.4. Cost estimates for constructing a road in the corridor are developed using quantities and unit prices for the major items. The following provides examples of major items:

   - clearing and grubbing per hectare (acre);
   - unclassified roadway excavation per cubic meter (cubic yard);
   - minor drainage per kilometer (mile);
   - surfacing and base per kilometer (mile);
   - paving (type) per kilometer (mile);
   - revegetation and landscaping per kilometer (mile);
   - major structures per each (identify);
   - right-of-way cost estimate per hectare (acre);
   - miscellaneous (include construction traffic control, guardrail, guide posts, fences, etc.); and

- an estimate of the user's cost both per kilometer (mile) and from termini to termini.

4.4.4.8 Corridor Study Report

Extensive corridor analyses are sometimes documented in a formal corridor study report that then can be considered a Conceptual Study Report. More frequently, though, this information is kept informal. In either case, corridor analyses are summarized in the major environmental documents (i.e., Environmental Assessment, Environmental Impact Statements). The corridor study reports not only contain the results of the corridor analyses but also summarize the preliminary design standards under consideration. In addition to the engineering information, the social, environmental and economic features of the alternatives (separate corridors) used in the analyses are presented at least in a general fashion.

The final study report should contain the following items:

1. **Introduction**. Describe the authority and purpose of the study.

2. **Organization**. Identify all sources of information, maps and data obtained for the study.

3. **Climate, Physiography and Geology**. Provide a description of the climate, significant geographic features, land uses and geology of the area.

4. **Preliminary Design Standards**. This section should include all traffic data and design criteria for the study.

5. **Corridor Descriptions**. Provide a detailed description of each corridor studied.

6. **Comparative Evaluation**. This section should contain a comparative evaluation of routes studied. Include a dissertation of the related social, economic and environmental (SEE) impacts (e.g., changes in land uses, displacement of residences, disruption of communities, environmental mitigation measures, construction costs, road user costs, secondary economic factors).

7. **Benefit Cost Analysis**. An optional section that may be used to provide a benefit cost analysis for each corridor and the basis for them.

8. **Exhibits**. Use exhibits to include route maps or aerial mosaics depicting the location of the corridors, typical roadway sections, vicinity maps, route profiles, physical characteristics outlined on reconnaissance study form and detailed cost estimates of alternatives.

4.5 APPROVALS

At the conclusion of conceptual studies, a decision must be made identifying which alternative is going to be advanced into the design phase. The decision-making process is described in Chapter 3.

4.5.1 Conceptual Engineering Studies

Since the results of the location analysis provide the critical engineering and/or reconnaissance information, array of alternatives and, in some cases, the preferred alternative to be contained in the public environmental document; these findings should be reviewed and concurred with by the appropriate Division staff who are responsible for the clearance of environmental documents. In addition, land management agencies should also review and concur in the engineering findings regardless of whether they have been documented by informal analyses or in complete, formal Conceptual (corridor) Study Reports. This will ensure the environmental process is evaluating alternatives that the land management agency is comfortable with. Concurrence of the report or informal findings does not constitute official approval of a specific alternative or issue authority to commence design activities.

4.5.2 Location Approval

Formal approval of the preferred alternative, traditionally referred to as location approval, occurs when the project's environmental clearance document is approved as described in Chapter 3, Section 3.5. This also completes the conceptual study phase and advances the project into the design phase and subsequent plans, specifications and estimates (PS&E) preparation.

The description of the preferred alternative contained in the environmental decision making documents (e.g., categorical exclusion, finding of no significant impact, record of decision) should include preliminary design standards and corridor information to ensure the project will be designed to implement the approved concept.

4.6 REPORTING

Conceptual studies provide findings and recommendations that are reviewed and commented on by various agencies and parties. This information can be reported to the agencies in various ways or combined in other documents.

4.6.1 Conceptual Engineering Study Reports

The results of the location analysis can be contained in a separate conceptual study report (e.g., corridor study report) or more commonly be documented in a less formal manner. Memorandums, trip reports or even semi-formal checklists can be used to record the conceptual study results. In any case, this information should be documented to ensure the findings and/or recommendations, as well as existing conditions, objectives, facts, assumptions and analyses can be reviewed and understood by all interested and affected parties. All improvement alternatives should be readily supportable from an engineering position, which is contained in these study documents.

If separate formal reports are prepared, they can be in different formats or detail, and should be only as formal as appropriate for that scale of project.

4.6.2 Environmental Documents

The engineering information and descriptions of the improvement alternatives contained in the environmental documents are summarized from the conceptual studies. Since the final location approval decisions are a product of the environmental process, it is imperative that environmental documents present the engineering data in an accurate, complete and understandable fashion. The content of environmental documents are described in Chapter 3.

4.7 DIVISION PROCEDURES

Reserved for Federal Lands Highway Division office used in supplementing policy and guidelines set forth in this Chapter with appropriate Division procedures and direction.

4.7.1 EFLHD Procedures

4.7.2 CFLHD Procedures

4.7.3 WFLHD Procedures